Neural coding of variable song structure in the songbird

Xavier Hinaut, Aurore Cazala, Catherine del Negro

Neural coding of variable song structure in the songbird

Xavier Hinaut[1234], Aurore Cazala[1], Catherine Del Negro[1]

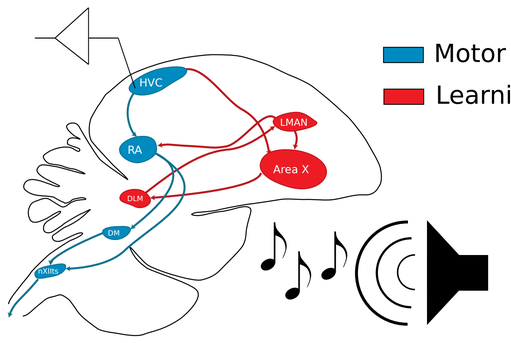
1 Université Paris Saclay, UMR 9197, Neuro-PSI, Orsay, France. 2 Inria Bordeaux Sud-Ouest, Talence, France. 3 LaBRI, UMR 5800, CNRS, Bordeaux INP, Université de Bordeaux, Talence, France. 4 Institut des Maladies Neurodégénératives, UMR 5293, CNRS, Université de Bordeaux, Bordeaux, France.

Introduction

Songbirds are an excellent model for exploring the neural coding of variable sequences of categorical acoustic elements. The domesticated canary, for instance, produce higly variable songs with complex transition rules between two consecutive acoustic elements. These transition rules are non-Markovian (i.e. the next acoustic element to be sung is dependent on several previous elements, not only the last one) [1].
In the HVC of Bengalese finches, Bouchard and Brainard [5] found that variations in responses to a given syllable could be explained by a positive linear dependence on the convergence probability of preceding sequences.
Here, we reanalyse data from [3] to see if similar findings could be found for canaries.

Goal

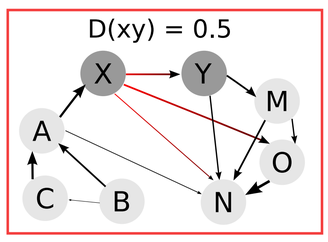
Our aim is to understand how complex song sequences produced by canaries are coded in a sensorimotor area, the HVC nucleus.

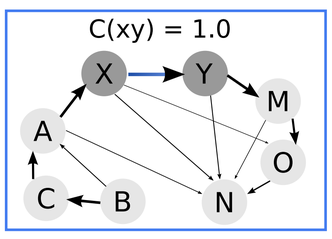


The **HVC** (somehow analogous to vocal premotor cortical areas) participates in generating **temporal organization** of acoustic elements within songs [2].
In the HVC of canaries, most of cells show auditory responses and are selective for the **bird's own song (BOS)** over its temporal variants (with a different order of acoustic elements) [3], but how the sequential structure (ordering of acoustic elements) is coded is poorly understood.

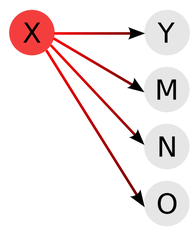
HYPOTHESIS
HVC neurons encode all or a subset of **syntax features** of the songs heard.

Song structure and ways to explore it





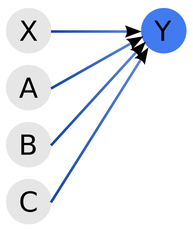
Divergence Probability



D(xy) = P(Y|X)

given 'X' what is the probability that 'Y' **follows**?

Convergence Probability



C(xy) = P(X|Y)

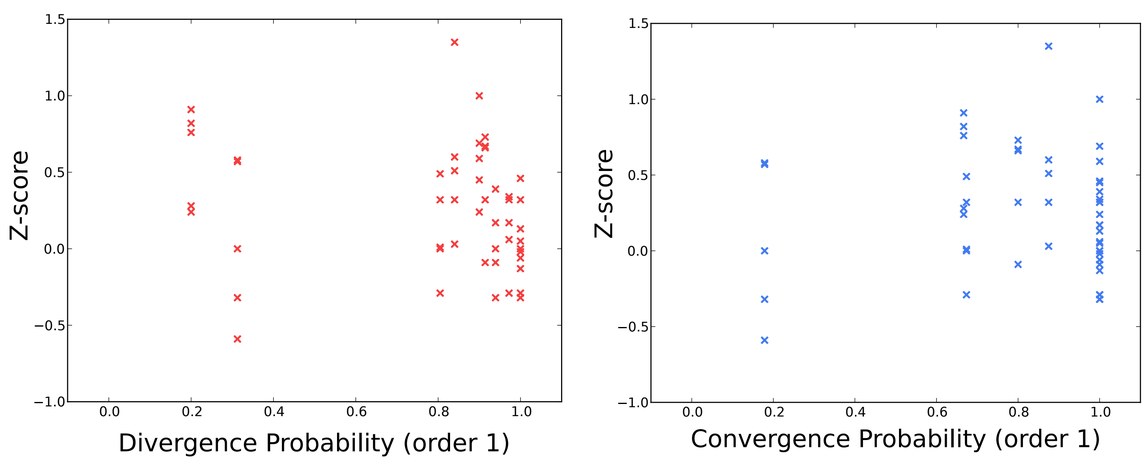
given 'Y' what is the probability that 'X' **precedes**?

Each canary has a **specific repertoire** composed of 15-35 distincs syllables (acoustic elements organized into sequences). According to [1], sequences of acoustic elements in canary songs show l**ong-distance dependencies** (e.g. **"chunks"**).

No correlation found btw responses and prob. div./conv.

Z-score vs. Probability

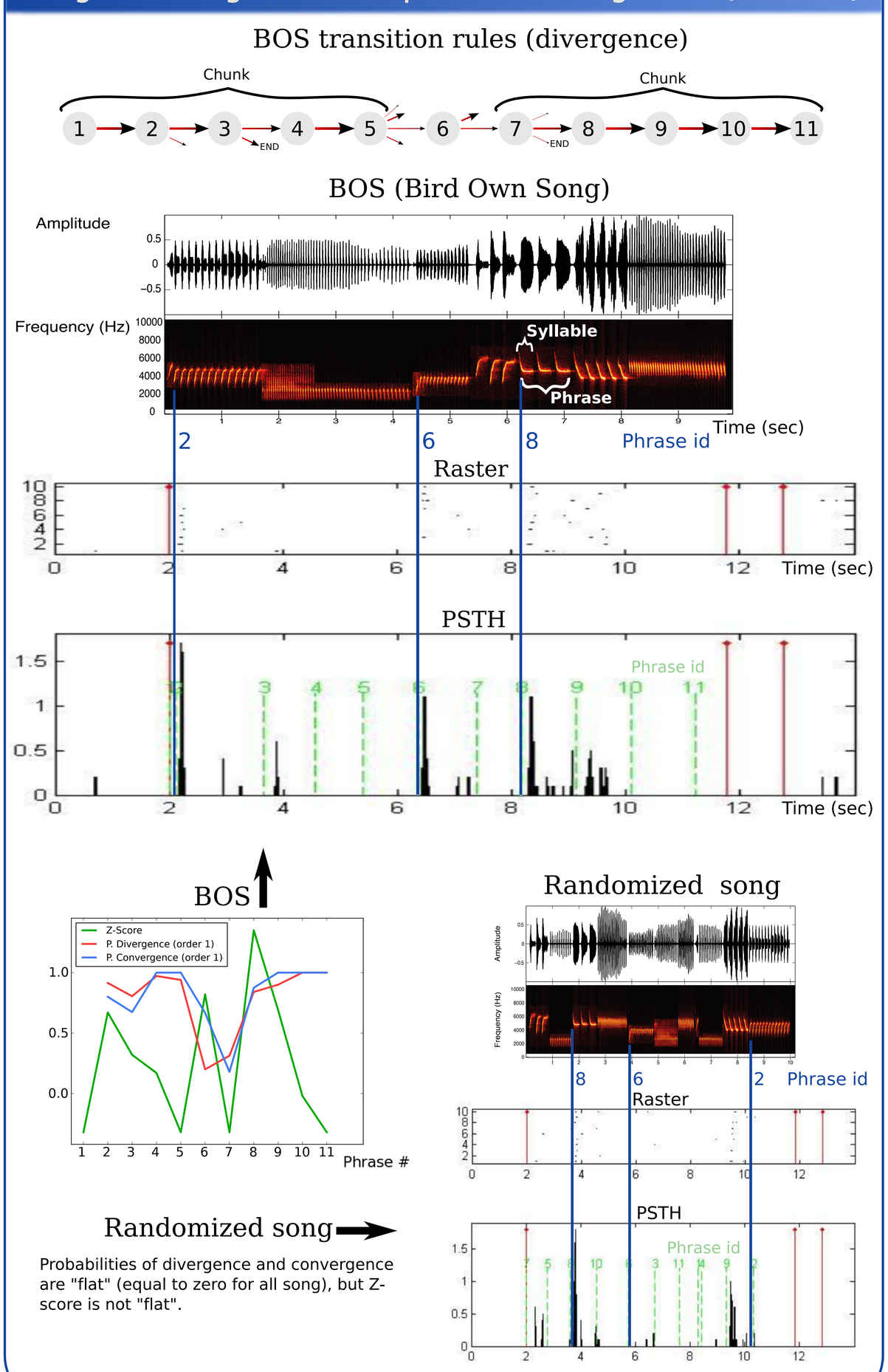
We found no correlation between phrases neuronal responses (firing rate or Z-score) for the BOS or the randomized song and their probability of divergence and convergence. Below: the Z-score for 5 units of one bird (S62) given probability of divergence (left) and convergence (right).



References

[1] Markovitz et al., PLoS Comp. Bio. (2013).
[2] Hahnloser et al., Nature (2002).
[3] Lehongre & Del Negro, Neurosci. (2011).
[4] Fujimoto et al., J. Neuro (2011).
[5] Bouchard & Brainard, J. Neuro. (2013).

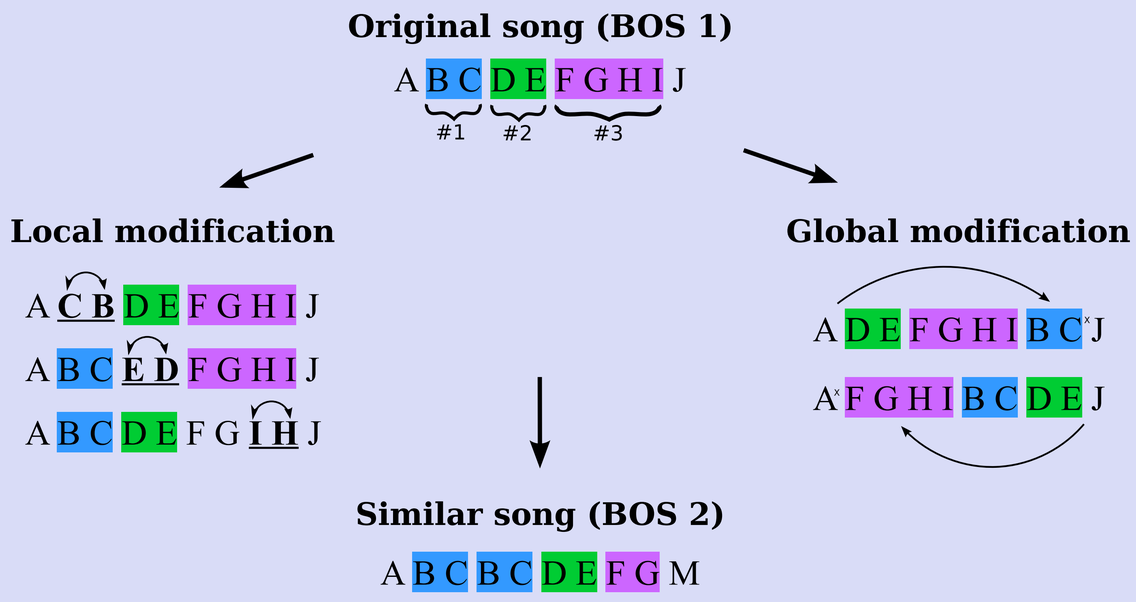
Songs and song-evoked responses of a single unit (bird S62)



Probabilities of divergence and convergence are "flat" (equal to zero for all song), but Z-score is not "flat".

Current work: studying responses to chunk modifications

In a new study, we recorded auditory responses in HVC of anesthetized canaries using multi-electrods arrays (8 or 16). We used as auditory stimuli the bird's own song (BOS) and modified versions of the BOS, in which we manipulated either the local or global structure. We reversed the position of two consecutive elements (**local**) or reordered parts of the song (**global**).



Acknowledgments
The work was supported by Project IDEX NeuroSaclay "From Sequence Learning to Language Acquisition". We would like to thank Nicolas Giret for his help and advises. Poster template inspired from http://quantum.opticsolomouc.org/archives/1026 under Creative Commons Attribution-ShareAlike 3.0 Unported License.

Contacts
xavier.hinaut@inria.fr, {aurore.cazala; catherine.del-negro}@u-psud.fr